

ME Fluorescent Lamp Study Follow-up

Executive Summary:

This follow-up study was conducted to answer the question of data variability for total mercury results reported in the ME Fluorescent Lamp Study completed in 2001. Undosed lamps were spiked and analyzed using the same protocol from the ME Fluorescent Lamp Study [referred to as the "original study" throughout this report].

Results from the spiked samples have much greater precision than the results from samples analyzed in the original study. Variability in the follow-up study spike results meets the original study QAPP requirement that the mean be determined with an accuracy of $\pm 10\%$ at the 95th percentile. These results are consistent with conclusions from the original study and suggest that factors other than the analytical method contribute to the variability in the sample results.

Background:

December 19, 2001 a final report was issued for a study of mercury levels in fluorescent lamps [ME Fluorescent Lamp Study]. In the original study new and used lamps from ten popular lamp models were collected and tested for total mercury and TCLP mercury by specialized testing procedures. Results indicated that lamps represented as TCLP-compliant have total mercury results similar to their non-compliant counterparts. Results for total mercury analyses did not meet the QAPP requirement that the mean be determined with an accuracy of $\pm 10\%$ at the 95th percentile. This was due to variability in the total mercury results for the 20 lamps analyzed in each lamp model.

Variability in the standard reference material [SRM] sample from the original study was calculated to give some indication whether the analytical method is too variable to meet the QAPP requirement or whether results reflect the true variability in mercury dosing of lamps. These results indicated that the method variability for the SRM is well within the project requirement. The SRM matrix is water, which is not subject to the same digestion challenges as lamp samples; however, it does demonstrate that any error contributions from the determinative portion of the analysis and error associated with dilution procedures are low. No spiked samples were run with the original study because each sample lamp was completely consumed in the testing process. The original study concluded that additional testing would be required to determine whether the digestion method for whole lamp analysis significantly contributed to the variability of the results.

Study Design:

Final Study design included analyzing undosed lamps from Osram-Sylvania and Philips Lighting. Osram-Sylvania provided undosed T8 and T12 lamps, and Philips provided undosed T8 lamps. For each of the three types of lamps, testing included 1 undosed lamp as a method blank and 10 undosed lamps that were spiked with 1 ml of a 3mg/ml spiking solution containing elemental mercury and then analyzed.

All lamps were sent directly to the laboratory that performed the original lamp study: Veritech Laboratories in Fairfield, NJ. The laboratory prepared the lamps as in the original study with the following modification: 1 ml of Environmental Resource Associates [ERA] custom spiking solution was added to each spiked sample prior to digestion. The concentration of the spiking solution was not known to the laboratory prior to analysis. All samples were digested and analyzed according to the standard operating procedure [SOP] used in the original study.

Laboratory results were compiled in full report packages including raw data according to procedures outlined in the original study, sent to and reviewed by Deb Stahler at the Maine Department of Environmental Protection [ME DEP]. Results were then compiled in an EXCEL spreadsheet and analyzed statistically including calculations for mean, mean percent recovery, and relative standard deviation. These statistics were compared to SRM and sample statistics from the original study.

Results:

Osram/ Sylvania T12 Lamps

SAMP NUM	LABID	SAMPDATE	DANALYZ	CONC ug/L	mg/ Lamp	Comments
T-12	AB51949	02/02/2002	02/22/2002	14	0.014	Method Blank
T-12 #1	AB51960	02/02/2002	02/22/2002	2900	2.9	Spike
T-12 #10	AB51969	02/02/2002	02/22/2002	2800	2.8	Spike
T-12 #11	AB53361	03/04/2002	03/20/2002	2600	2.6	Spike
T-12 #2	AB51961	02/02/2002	02/22/2002	2600	2.6	Spike
T-12 #3	AB51962	02/02/2002	02/22/2002	2900	2.9	Spike
T-12 #4	AB51963	02/02/2002	02/22/2002	2800	2.8	Spike
T-12 #5	AB51964	02/02/2002	02/22/2002	3000	3	Spike
T-12 #6	AB51965	02/02/2002	02/22/2002	3000	3	Spike
T-12 #7	AB51966	02/02/2002	02/22/2002	2900	2.9	Spike
T-12 #8	AB51967	02/02/2002	02/22/2002	2800	2.8	Spike
T-12 #9	AB51968	02/02/2002	02/22/2002	2900	2.9	Spike
				mean	2.8	
				% recovery	95	
				STDEV	0.1362	
				Lower CI	2.7	
				Upper CI	2.9	
				RSD	4.8	

Osram/ Sylvania T8 Lamps

SAMP NUM	LABID	SAMPDATE	DANALYZ	CONC ug/L	mg/ Lamp	Comments
T-8	AB51948	02/02/2002	02/22/2002	0	0	Method Blank
T-8 #1	AB51950	02/02/2002	02/22/2002	2700	2.7	Spike
T-8 #10	AB51959	02/02/2002	02/22/2002	2800	2.8	Spike
T-8 #11	AB53360	03/04/2002	03/20/2002	2700	2.7	Spike
T-8 #2	AB51951	02/02/2002	02/22/2002	2700	2.7	Spike
T-8 #3	AB51952	02/02/2002	02/22/2002	2600	2.6	Spike
T-8 #4	AB51953	02/02/2002	02/22/2002	2500	2.5	Spike
T-8 #5	AB51954	02/02/2002	02/22/2002	2800	2.8	Spike
T-8 #6	AB51955	02/02/2002	02/22/2002	2900	2.9	Spike
T-8 #7	AB51956	02/02/2002	02/22/2002	2800	2.8	Spike
T-8 #8	AB51957	02/02/2002	02/22/2002	2800	2.8	Spike
T-8 #9	AB51958	02/02/2002	02/22/2002	2800	2.8	Spike
				mean	2.7	
				% recovery	91	
				STDEV	0.1120	
				Lower CI	2.7	
				Upper CI	2.8	
				RSD	4.1	

Philips Lighting T8 Lamps

SAMPNUM	LABID	SAMPDATE	DANALYZ	CONC ug/L	mg/ Lamp	Comment
F32T8	AB54932	03/28/2002	04/11/2002	0	0	Method Blank
F32T8 #1	AB54933	03/28/2002	04/11/2002	2700	2.7	Spike
F32T8 #2	AB54934	03/28/2002	04/11/2002	2600	2.6	Spike
F32T8 #3	AB54935	03/28/2002	04/11/2002	2800	2.8	Spike
F32T8 #4	AB54936	03/28/2002	04/11/2002	2800	2.8	Spike
F32T8 #5	AB54937	03/28/2002	04/11/2002	2700	2.7	Spike
F32T8 #6	AB54938	03/28/2002	04/11/2002	3000	3	Spike
F32T8 #7	AB54939	03/28/2002	04/11/2002	2800	2.8	Spike
F32T8 #8	AB54940	03/28/2002	04/11/2002	2800	2.8	Spike
F32T8 #9	AB54941	03/28/2002	04/11/2002	2400	2.4	Spike
F32T8 #10	AB54942	03/28/2002	04/11/2002	2400	2.4	Spike
				mean	2.7	
				% recovery	90	
				STDEV	0.1886	
				Lower CI	2.6	
				Upper CI	2.8	
				RSD	7.0	

Discussion:

Review of the lamp data packages indicated that all QC requirements were met, and results were acceptable without qualification.

Accuracy and precision measurements from the spiked lamps in the follow-up study are similar to statistics for the standard reference material [SRM] analyzed during the original study. The table below gives a comparison of these measurements. True value for the SRM and the spiked lamps is 3.0 mg/lamp.

Statistic:	SRM [original study]	OSI T8	OSI T12	Philips T8
Mean	3.0	2.7	2.8	2.7
Mean Percent Recovery	101%	91%	95%	90%
Lower CI	2.9	2.7	2.7	2.6
Upper CI	3.1	2.8	2.9	2.8
RSD	6.4%	4.1%	4.8%	7.0%

Results are in mg/ lamp unless otherwise indicated.

Relative Standard Deviation [RSD] is a measure of precision. RSD is below 10% for the SRM and spiked lamps, which indicates that variability is low, precision is high. In comparison, the RSD for lamps in the original study [by lamp model] is much higher, indicating a higher degree of variability and lower precision. The following table shows the comparison of RSD for lamp models, SRM and spiked lamps.

Lamp Model	RSD [%]
13803	60.2
15949	41.0
23010	45.2
26668	53.5
24470-7	32.9
27248-4	26.3
21824	47.1
21999	39.5
24594	68.2
24596	33.3
SRM	6.4
OSI T8 spk	4.1
OSI T12 spk	4.8
Philips T8 spk	7.0

These results suggest that factors other than the analytical method contribute to the variability in the sample results.

It could be argued that results from lamps spiked with a spiking solution are not representative of the actual matrix. It is difficult to spike a lamp in such a way as to represent the true complexities of the matrix. When lamps are manufactured, elemental mercury is added to the lamp, along with other substances, forming a "phosphor powder". When samples are "spiked" in the laboratory, the lamp is first disassembled and crushed in the digestion vessel, and then 1 ml of an acidified elemental mercury solution is added to the crushed lamp.

Matrix interference considerations include:

1. The spiking solution contains nitric acid which keeps the mercury in solution rather than having it adhere to the lamp surfaces.
2. Using a spiking solution also assures that mercury does not quickly vaporize from the sample before analysis.
3. Chemical reactions between mercury and other lamp components may occur in standard lamps, which do not have time to occur in the spiked/ undosed lamps.

These considerations are not within the scope of the follow-up study, and would be difficult to determine.

Conclusions:

Results from this study are consistent with conclusions from the original study, and suggest that factors other than the analytical method contribute to the variability in the sample results. However, questions about the representativeness of the spiked samples cloud the results and do not allow this to be clearly confirmed. More work, which is beyond the scope of this study, would be needed to investigate considerations of matrix interference.